

3.31 RESULTS FOR GUN MOVEMENT

The following assessment of gun movement is based upon comparisons between gun servo transient response plots shown in Reference 7 and model output transient response plots for the same system. The model should produce transient response plots similar to those shown in the reference in terms of percentage overshoot, peak time, rise time, and settling time. Results for this assessment are shown in Table 3.31-1.

TABLE 3.31-1. Summary of Results for Gun Movement.

Data Source	Major Conditions	Statistical MOEs	% Difference
Reference 7 - azimuth and elevation step response curves	S&TI - conditions unknown	Percent Overshoot	3
		Peak Time	10
		Rise Time (to 90%)	12
		Settling Time ($\pm 10\%$)	1

3.31.1 Assessment – Case 1

Test Data Description. Appendix I of Reference 7 contains a detailed discussion of the azimuth turret positioning servo and the elevation gun positioning servo. Block diagrams are given for each as well as frequency and phase response plots for many of the individual subsystems in the diagrams. The appendix also contains closed-loop transient response plots to steps of 1.5 and 3.0 degrees in azimuth and elevation. It is assumed that these are modeled responses.

Validation Methodology. In *RADGUNS*, the azimuth and elevation gun-positioning servo systems are modeled by single transfer functions of the form:

$$\frac{G(s)}{C(s)} = \frac{k_1 s^2 + k_2 s + k_3}{s^3 + k_4 s^2 + k_5 s + k_6}$$

where: $G(s)$ = Turret azimuth or elevation
 $C(s)$ = Commanded aim azimuth or elevation
 k_i = System parameters, different for azimuth and elevation
 s = Laplace operator, $j(\omega)$

In the implementation of this particular system, the coefficients used in the above equation were empirically derived to produce transient response plots similar to those shown in Reference 7. The response of the system to an error input is found by solving the above equation in the time domain.

The following procedure was used to produce transient response plots in the model. The radar was used to track a stationary target inside the system's tactical range. The fire-control commanded azimuth and elevation aim points were bypassed by setting variables BETAP and PHIP to 0 mrad for 3 s, then to 26.18 mrad (1.5 deg) for 5 s. The resulting turret azimuth and barrel elevation (GUNAZ and GUNEL) were written to an external file. The normalized step response was computed by dividing the resultant output by the input step size. This procedure was repeated for a 62.36 mrad (3.0 deg) step.

Results

A comparison of modeled (labeled *RADGUNS* v.1.9) and Reference 7 (labeled REF7) transient responses to azimuth steps of 1.5 and 3.0 deg is shown in Figure 3.31-1. A similar plot is shown for elevation in Figure 3.31-2.

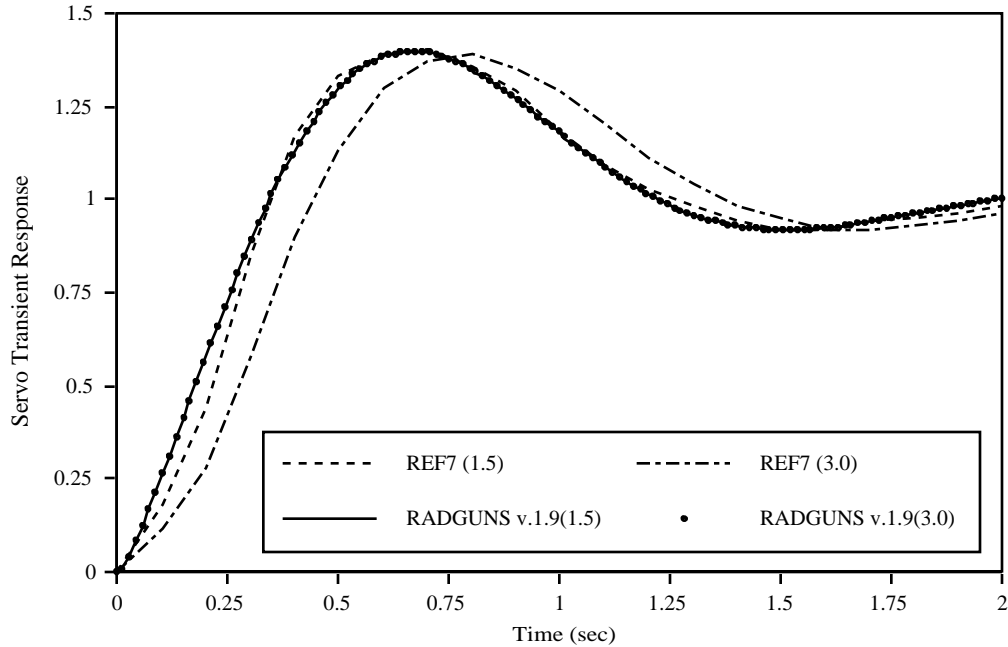


FIGURE 3.31-1. Turret-Positioning Servo Transient Response.

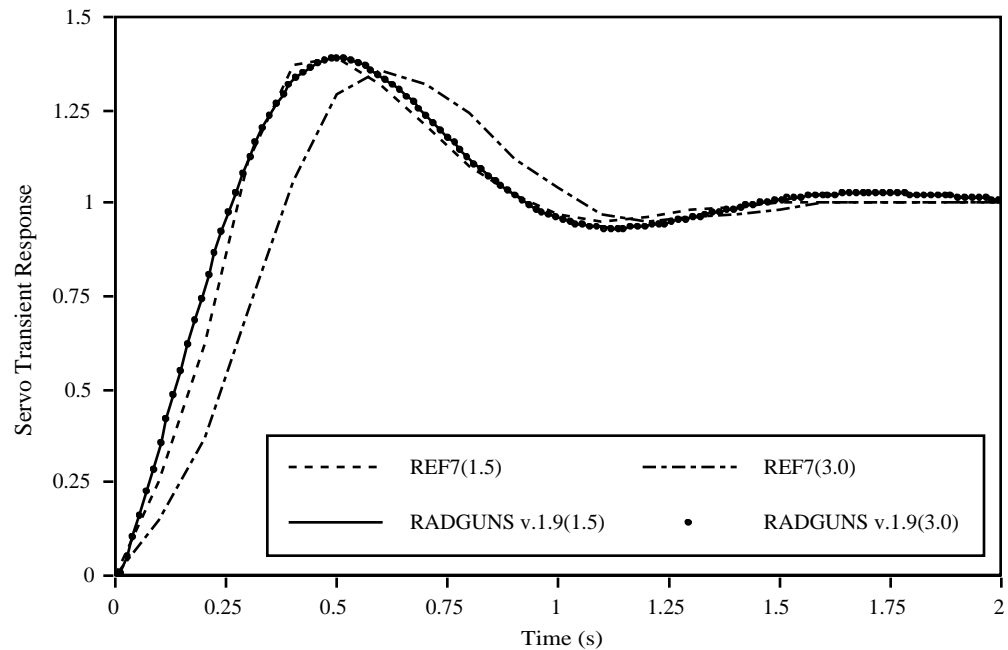


FIGURE 3.31-2. Elevation Gun-Positioning Servo Transient Response.

Each of these plots can be characterized in terms of percent overshoot, peak time, rise time to 90%, and settling time to within show these characteristics for both the azimuth and elevation gun-positioning servos for both step sizes. The values for both the reference and the model are given as well as the percentage difference between them.

TABLE 3.31-2. Comparison of Gun Azimuth Transient Response Characteristics.

Step Response Characteristics	Reference 7		<i>RADGUNS</i> v.1.9		% Difference	
	1.5 deg	3.0 deg	1.5 deg	3.0 deg	1.5 deg	3.0 deg
% Overshoot	39	39	40	40	2.6	2.6
Peak Time (s)	0.60	0.80	0.66	0.66	10.0	17.5
Rise Time (s)	0.32	0.40	0.31	0.31	3.1	22.5
Settling Time (s)	1.1	1.2	1.1	1.1	0	8.3

TABLE 3.31-3. Comparison of Gun Elevation Transient Response Characteristics.

Step Response Characteristics	Reference 7		<i>RADGUNS</i> v.1.9		% Difference	
	1.5 deg	3.0 deg	1.5 deg	3.0 deg	1.5 deg	3.0 deg
% Overshoot	39	36	39	39	0	8.3
Peak Time (s)	0.5	0.6	0.5	0.5	0	16.7
Rise Time (s)	0.26	0.35	0.23	0.23	11.5	34.3
Settling Time (s)	0.80	0.93	0.81	0.81	1.3	12.9

Conclusions

Although the overshoot shown in Reference 7 is the same for both azimuth step sizes, the larger step exhibits longer rise, peak, and settling times. The larger elevation step produces a smaller percent overshoot and longer rise, peak, and settling times. The response produced by *RADGUNS*, however, is independent of step size and closely matches the intel response for a 1.5 deg step. The modeled response to a 3.0 deg step differs from the response shown in the reference by as much as 34% in terms of rise time. This difference, although large, is probably insignificant because the gun servos are updated on a scan-by-scan basis. For this reason, it is unlikely that a large step (on the order of 3.0 deg) will be input except perhaps when the guns are initially pointed at the target or when the system breaks lock and reacquires a target.

